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HIGH TEMPERATURE PROPERTIES OF SODIUM AND POTASSIUM

Eight Progress Report
For Period 1 July to 30 September 1962

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ABSTRACT

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A research program is in progress at this Laboratory for the determination of various thermophysical properties of the alkali metals, sodium and potassium, at elevated temperatures. The status of each property test is discussed, and preliminary data are presented concerning the equilibrium solubility of columbium in liquid sodium in the temperature range 1479° to 2518°F.

PROBLEM STATUS

This is an interim report on the problem; work is continuing.

AUTHORIZATION

NRL Problem C05-15, NASA Contract Number NAS C-76320
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INTRODUCTION

In the scope and development of highly efficient and compact electrical generating systems, the National Aeronautics and Space Administration is sponsoring a property measurement program for the evaluation of several liquid metals as possible working fluids. As an integral part of this program, the U. S. Naval Research Laboratory is engaged in the measurement of several thermophysical properties of sodium to 2500°F and potassium to 2100°F.

EXPERIMENTAL PROGRAM

The complete program for fiscal 1963 has been outlined in Reference 1. Some preliminary data have been reported (Ref. 1) on the solubility in liquid sodium of the columbium constituent of the Cb-1%Zr alloy to 2500°F. In addition, preliminary values for the density of sodium to 2500°F (Ref. 2) and potassium (Ref. 1) to 2200°F have been reported.

INDIVIDUAL PROPERTY TESTS

Equilibrium Solubilities of Columbium and Zirconium in Liquid Sodium

A radiochemical method (Ref. 3) is being used to determine the equilibrium solubilities of the Cb-1%Zr alloy in liquid sodium to 2500°F. The analytical scheme, in essence, employs the inactive carrier technique for a solute measurement of the constituent elements of the alloy. The equilibrated sodium samples are chemically processed into aqueous solutions and the columbium and zirconium are coprecipitated with Fe carrier as hydrous oxides. After ignition of precipitate to the oxide, the samples, with standard comparators, are irradiated in the NRL Swimming Pool Reactor. A radiometric comparison of the characteristic radiation induced in the samples and the standards provides a measure of the solubilities of the constituent elements in liquid sodium.

Previously reported data (Ref. 1) on the solubility of columbium in sodium showed a high degree of inconsistency. In an attempt to resolve this and also to establish the solubility equilibration rate, a series of four experiments have been completed in which the sodium melts were held at temperature for a period of 8 hours in the range of 1479° to 2418°F. The results are presented in Table 1.

TABLE 1

EQUILIBRIUM SOLUBILITIES OF COLUMBIUM IN SODIUM
(Equilibration Time, 8 Hours)

Temperature (°F)	Solubility of Cb (ppm)
1479	17.9
1846	7.4
2185	35.0
2518	243.0

In the temperature range from 1479° to 2518°F the data for the log concentration of columbium versus the reciprocal of the absolute temperature (Fig. 1), except for one experimental point, can be represented by a straight line. From an experimental viewpoint, no obvious explanation for the high solubility in the experiment at 1479°F is evident. The equilibration vessel due to its malleability after the thermal treatment, is opened with ease using pipe cutters, but it is possible in the process of opening the sample compartment (Ref. 3) that a small particle of the columbium alloy was deposited in the sodium and carried through the analytical scheme. It may be possible to determine the origin of the high columbium concentration for this particular experiment by an analysis of the four Fe scavenged samples for zirconium content and then comparing the columbium to zirconium ratio for these samples with that of the original alloy material. A columbium to zirconium ratio comparable to that of the original container material for the 1479° experiment versus a different ratio for the other three samples would support the columbium values from the higher temperature experiments, and an extrapolation of the apparent solubility curve (Fig. 1) back to 1479°F would then indicate a solubility value of less than 1 ppm, which is below the sensitivity of the analytical method being used.

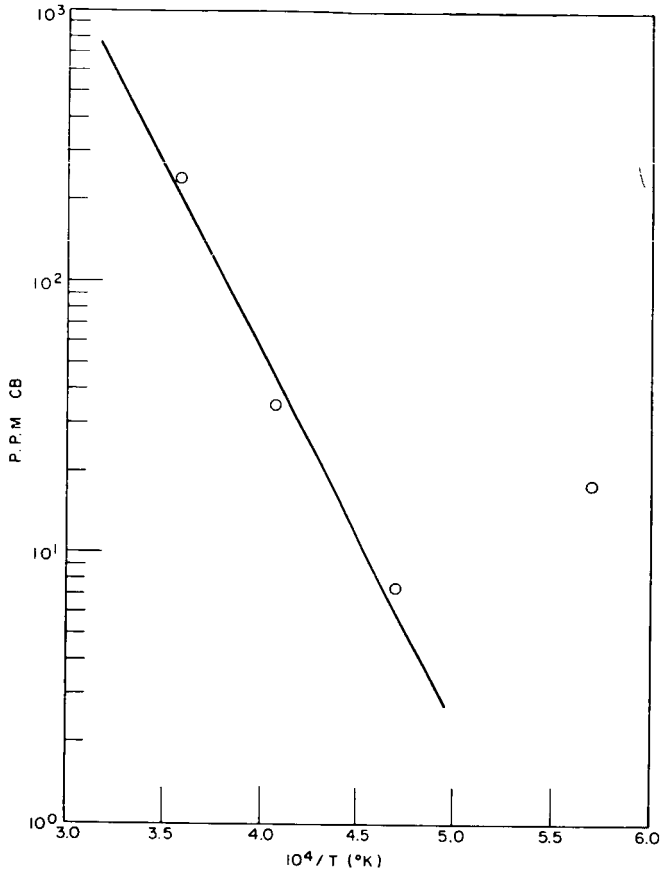

Fig. 1 - Log concentration of columbium vs the reciprocal of the absolute temperature (1479 to 2518)

The Fe carrier samples from the four solubility experiments are being readied for re-irradiation in the reactor for zirconium determinations, and solubilities of this constituent element will be subsequently reported. Further solubility testing will be deferred pending a completion of the zirconium analyses and interpretation of the results.

Pressure-Volume-Temperature

Problems, associated with the inclusion of inert gas in the chamber during welding operations and with the reproducibility of diaphragm movement, are being solved. Successful null-point experiments with sodium to 2500°F have been made in which there was no measurable gas inclusion, and with diaphragm movements reproducible to within ±0.2 lb./sq. in. Since a number of experiments are required to evaluate and compute meaningful P-V-T results, detailed reporting of this work will be delayed until additional experiments have been performed.

Specific Heat

Heat content measurements of sodium are in progress, and results should be available for the next report.

Density

Additional pycnometers have been prepared, and further measurements at lower temperatures on both sodium and potassium will be made.

Surface Tension

The maximum bubble pressure apparatus forthe surface tension determinations of liquid potassium (Ref. 1) has been designed, and the machining work is being performed. These measurements will require modifications to one of the existing furnace systems and will be performed as permitted by the P-V-T tests.

REFERENCES

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